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Computational Procedure for Finite Difference Solution of One-Dimensional Heat Conduction Problems Reduces Computer Time

The problem:

In solving ablation problems for which the mathematical model chosen to describe the ablation process is involved and/or for which the boundary conditions are not simple, numerical methods are usually employed. One of the most popular numerical techniques used for solution of this type of problem is the method of finite differences. Although this method is extremely powerful, in the practical use of this technique the economics (high computer-time cost) of problem solution is still a factor of consideration.

The solution:

A computational procedure for reducing the numerical effort whenever the method of finite differences is used to solve ablation problems for which the surface recession is large relative to the initial slab thickness.

How it's done:

A computational procedure for the finite difference solution of one-dimensional heat conducting problems with surface recession is particularly suited for problems in which the surface movement is large relative to the initial slab thickness and for which numerous time steps are involved. For definiteness, the problem of an ablating slab has been chosen; however, the method is not restricted to this specific problem. The finite difference scheme selected is arbitrary, although reference is made to the standard forward (explicit) differencing method and to the mid and backward

(implicit) differencing schemes. The primary advantage in this computational procedure is in the reduction of the number of numerical operations required for a given maximum space mesh size, with smoothness retained at the moving surface.

Notes:

1. To establish the relative effectiveness of the computational procedure, a representative problem was chosen and run on the IBM 7094. The initial slab thickness was 1.000 inch, and the final thickness was calculated to be 0.327 inch. The rate of surface recession was 0.00096 inch per second during the 700 second heating period, and a cooling (soak) interval of 400 seconds, immediately following the heating period, was then considered. Two cases were run for comparison purposes. The first case consisted of starting with 20 ablator and 7 substructure mesh points and ending with the original number of points. The second case started with the same 27 mesh points but ended with 14 points and used an interpolated value of temperature routine. The same calculation interval (time mesh size) was used for both cases. Excluding the cost for reading in data and for printing results, the cost of case two was 21 percent less than that of case one. The cost of reading in data and for printing was 48 percent of the total cost. Although this specific example cannot be generalized to all cases, it does, however, give some indication as to the effectiveness of the procedure for solution of problems of this type,

(continued overleaf)

2. Further information concerning this invention is given in "A Computational Procedure for the Finite Difference Solution of One-Dimensional Heat Conduction Problems with Surface Recession," by H. T. Iida, Report No. SID 65-1252, North American Aviation, Inc., November 1965. Copies may be obtained from:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas 77058
Reference: B66-10566

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: H. T. Iida
of North American Aviation, Inc.
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